Robert L. Bates

JOURNAL
of
GEOLOGICAL EDUCATION

Vol. 1, No. 3

The Association of Geology Teachers
April, 1952

JOURNAL

of

GEOLOGICAL EDUCATION

Vol. 1, No. 3

The Association of Geology Teachers

April, 1952

Copyright 1952 by
The Association of Geology Teachers

THE JOURNAL OF GEOLOGICAL EDUCATION

The Journal of Geological Education is published semiannually by the Association of Geology Teachers.

The annual subscription price is $2.00. Single issues are $1.15. Make checks payable to William F. Read, editor, Lawrence College, Appleton, Wisconsin.

All persons interested in geological education are invited to contribute. Manuscripts should be addressed to the editor. Brief comments and discussion are also welcome.

The Editorial Committee consists of Arthur L. Howland, Northwestern University; F. M. Fryxell, Augustana College; Lawrence Whitcomb, Lehigh University; Kurt E. Lowe, City College of New York; and William F. Read, Lawrence College.

C O N T E N T S

"The First Milestone," Kurt E. Lowe ---------- Page 1

"Notes and News" ---------- 4

"Geology in Popular Education," George A. Thiel --- 9

"Changing Requirements in Chemistry, Physics, and Mathematics for Geology Majors," H. R. Gault ---------- 13

"Geology in General Education Courses," James Brice ---------- 18

"Geology in the Physical Sciences Course in the College of the University of Chicago," Lou Williams Page ---------- 25

"Holding Student Interest in Historical Geology," Percival Robertson ---------- 34

"Use of Hand Specimens in Petrology Laboratory," A. O. Woodford ---------- 42

"A Three-Dimensional Teaching Aid in Structural Geology," Chauncy D. Holmes ---------- 46

"The Seminar as a Senior Polishing Course," John E. Allen ---------- 50

"Articles of Interest to Geology Teachers which Have Appeared in Ward's Natural Science Bulletin," David E. Jensen ---------- 59

THE FIRST MILESTONE

A Message from the National President of the Association of Geology Teachers

Fourteen years ago this May a small group of geologists in the Middle West, dedicated to the teaching of their science, founded the Association of Geology Teachers. Their plan boldly envisaged an organization of national scope and prominence. Membership increased steadily, though slowly, and remained confined on the whole to the central states. The intervening war years hampered expansion, but could not halt the spread of a great idea.

On November 18, 1950, an Eastern Section of the Association was formed by geology teachers attending the annual meeting of the Geological Society of America in Washington, D. C. The swift growth of this new group finally lead to a joint meeting with the original Midwest (now Central) Section at Detroit on November 10, 1951. There a national constitution was drawn up and the following national officers were elected:

President---Kurt E. Lowe, City College of New York
Vice-Pres.--Percival Robertson, The Principia
Secretary---Ralph Digman, Harpur College
Treasurer---Gerald M. Friedman, Univ. of Cincinnati
Editor------William F. Read, Lawrence College

With ratification of the constitution by overwhelming vote of the membership, the dream of the founders was at last realized. The first milestone had been reached.

Gratifying as this achievement may be, there is no time for complacency. The total membership now stands at approximately 160, representing some ninety-five institutions and organizations in twenty-seven states, Hawaii, the District of Columbia, and Canada. A tremendous job of "spreading the gospel" is still ahead of us. There were no less than 180 institutions

in the U. S. alone which granted bachelor degrees in geology during 1949-1950 (A.G.I. Newsletter, April, 1951). If we add to this the number of Canadian institutions--plus secondary schools, geological surveys, industrial organizations, etc.--individuals actively engaged in disseminating geological information must be reckoned in the thousands. Each one of these is a potential Association member.

The problem is to devise ways and means of "reaching" such individuals and of arousing their interest in the aims and purposes of our Association as expressed in Article II of the national constitution: "The purpose of this Association shall be to foster improvement in the teaching of the earth sciences at all levels of formal and informal instruction, to emphasize the cultural significance of the earth sciences, and to disseminate knowledge in this field to the general public."

The recently established national organization was conceived as an overall coordinating and organizing agency rather than as a source of direction and control. The implementation of the Association's aims and principles must of necessity come from its members working in regional groups, or "sections". Our immediate concern, therefore, is the organization of sections throughout the United States and Canada. Toward this end the Association has adopted a tentative division of the U. S. into ten geographic regions. We are happy to report that considerable interest has been shown in the formation of a New England and a Southeastern Section. In addition, the rather far-flung Central Section is contemplating division into a West Central and an East Central Section. But more--far more--must be accomplished before we can say we have reached the second milestone.

Let those who subscribe to our credo and who are willing to give freely of their time and energy come forward. The national officers stand ready to help in organizing a section in your region. Just drop a line to Kurt E. Lowe, Dept. of Geology, City College

of N. Y., 139th Street & Convent Ave., New York 31, or to Ralph Digman, Dept. of Geology, Harpur College, Endicott, N. Y., and you will receive the necessary data without delay.

Kirt E. Lowe.

NOTES AND NEWS

The New National Organization. Professor Lowe's letter, "The First Milestone", which appears at the beginning of this issue, states the essential facts regarding the establishment of the new national organization of the Association of Geology Teachers. Until the founding of the Eastern Section in November, 1950, the Association was undivided. Though its center of gravity was definitely in the Midwest, there were members from many states throughout the Union and the Association considered itself national in scope. The desirability of sectionalization had, however, long been recognized. Establishment of the Eastern Section was encouraged by the parent group. When this event actually occurred, however, the question presented itself whether the new section was to be a subdivision of the original Association, or whether it was to be on an equal footing. Had the first alternative been followed, the Midwest organization would have remained the national organization, and a new Midwest sectional organization would have been called for to balance the Eastern Section. It was agreed from the start, however, that the Eastern group should be on an equal footing with the one already in existence. Consequently, the original national organization found itself automatically demoted in the fall of 1950 to a sectional organization, and though no official action was taken, it took the name thenceforth of "Central Section". Almost immediately the need was felt for some sort of a national superstructure to coordinate the activities of the two separate sections, promote the founding of new sections, and develop projects (like the Journal) of interest to all. The new national organization is the answer to this need.

Section Meetings. The Eastern Section of the Association of Geology Teachers met at Vassar College on April 4-5. The Midwest Section had its meeting at Kent State University, Kent, Ohio, on April 18-19. Reports on these meetings will appear in the next issue of the Journal.

Further Notes on "Geology: Gaining or Losing". On page 3 of the preceding issue of the Journal, it was pointed out that returns on questionnaires from thirty-seven states indicated that three new geology departments were being started in the academic year 1951-52 as against four departments dropped. Returns subsequently received throw further weight on the "losing" side of the balance. Kentucky, Ohio, and the District of Columbia each report the dropping of a geology department, and a second loss is reported from Illinois. In two of these cases the loss is said to be temporary. With eight states still not heard from the score now stands at seven losses versus three gains--not a very encouraging picture.

The Education Committee of the American Geological Institute. Under the chairmanship of Professor George A. Thiel of the University of Minnesota, the A.G.I. Committee on Education established regional subcommittees in Arizona, Colorado, Illinois, Michigan, Minnesota, New England, New York, North and South Dakota, Ohio, Oklahoma, Pennsylvania, the Southeastern States, Tennessee, Washington-Oregon, and Wisconsin. A report on the activities of these subcommittees, and on the work of the central committee, was submitted to the Institute in November, 1951. The Education Committee, like the Association of Geology Teachers, has been interested in furthering the spread of geological education by all means and at all levels. Some local subcommittees tell of real gains in their areas. Education of the general public by means of lectures, television shows, radio talks, and exhibits is on the increase. In North Dakota geology has been officially approved as part of the high school curriculum. In Illinois field trips have been organized by the State Geological Survey to instruct high school teachers and others in features of the local geology. In Pennsylvania, the Geology Department at Franklin and Marshall College has prepared a film entitled "The Geologist at Work" and shown it at many high schools and service clubs. In Minnesota, more geology has been written into study guides on conservation for instruction at the grade-school level.

The Central Committee, besides coordinating and encouraging the work of subcommittees, has been engaged in projects of its own. In an inventory of the geological offerings of 509 "institutions of higher learning" in 15 states, they found that 60% offered no geology at all; 9% offered a little geology in other courses; 15% had several regular geology courses; 9% offered enough courses for an undergraduate geology major; and 6% offered graduate work in geology leading to advanced degrees. The committee acted as co-sponsor of the Second Annual Conference on the Teaching of Earth Science in Secondary Schools (See page 1 of the last issue of the Journal). It has been working on the preparation of a list of films and film strips on Earth Science for use at the primary and secondary school levels.

Brief notes on the Committee's work were carried in the December, 1951, issue of the A.G.I. Newsletter. The full report has been mimeographed, and presumably copies may be secured from Institute headquarters.

Chairmanship of the Education Committee has now passed from Professor Thiel to Dr. Sheldon Judson of the University of Wisconsin.

Sigma Gamma Epsilon held its biennial national convention at Hot Springs, Arkansas, on December 8, 1951. Sigma Gamma Epsilon was founded in 1915 at the University of Kansas as an honorary society for graduate or undergraduate students majoring in some branch of the Earth Sciences. Today there are forty-five chapters in the United States and Canada with a total membership of approximately 2000. The main purpose of the society, as stated by the national secretary-treasurer, William R. Higgs of the Missouri School of Mines and Metallurgy, is "to draw together students in the Earth Sciences for the better understanding of their many separate fields." New chapters may be established upon written petition by not less than five eligible students at a recognized college or university. The petition must be accompanied by a letter from the chairman of the department in which the students are majoring.

Earth Science Digest. A recent issue of the A.G.I. Newsletter carries the welcome information that the Earth Science Digest, which suspended publication about a year ago, will soon be revived. Not least among the Digest's past contributions to geological education was its full report on the First Conference on the Teaching of Earth Science in Secondary Schools, held in March, 1950, under the chairmanship of Prof. C. Wroe Wolfe of Boston University. The preceding issue of the Journal of Geological Education carried brief notes on the second conference, which was held during the period when the Earth Science Digest was out of commission. A third conference was held at the Choate School, Wallingford, Conn., on March 15 of this year. It is hoped that the new Earth Science Digest will carry a full account of this meeting. The first issue is scheduled for publication in June. Subscriptions ($2.00) should be mailed to Russel P. McFall, Business Manager, P.O. Box 1357, Chicago 90.

Corrections to October, 1951, Issue. Various errors creep into papers published in the Journal. Some few, of course, are errors made by the authors. Others, unfortunately, are chargeable to the Journal editor. Sometimes the typist makes mistakes in preparing final photocopy from manuscript, and the editor fails to catch them. Other editorial errors result from the fact that issue material is not gotten together long enough in advance to permit re-checking by authors of all editorial changes in the original manuscripts.

An unfortunate error of the latter sort appeared on page 8 of our preceding issue in the article on "Popular Geology" by Arthur Montgomery. Referring to the series of quadrangle reports prepared for the New Hampshire Planning and Development Commission under the leadership of Professor Billings of Harvard University, the article states that these reports were published "over fifteen years ago". It should state that they were published over a fifteen year period.

Several more errors appear in the paper by Donald M. Henderson on "The Sizes of Atoms and the Study of Elementary Mineralogy". The most serious are as follows: The second sentence on page 27 reads, "Certain positions in such structures may be occupied by atoms varying considerably in size without distorting the structure, though they may cause it to become unstable." The latter part of this sentence should read, "without distorting the structure enough to make it unstable." The third paragraph on page 27 reads, "Pressure may affect isomorphism, but to a considerably lesser degree than temperature, by modifying slightly the relative sizes of atoms." The latter part of this sentence should read, "possibly by modifying slightly the relative sizes of atoms, or by affecting the 'structural resiliency'." The first paragraph on page 29 contains the statement, "0.732 is the limiting ratio between a cubic and an octahedral type of arrangement." "Cubic" and "octahedral" should be in quotes. As Mr. Henderson points out, the use of these words without quotes implies an erroneous conception of the relation of crystal structure to morphology. The first paragraph on page 37 contains the statement that "the formation of a given kind of tetrahedral grouping is probably a response to extremely complex interplay of factors of a thermodynamic nature which control the relative number of available atoms taken up by Si." Two words were omitted in this statement: "an" before "extremely" and "O" before "atoms".

GEOLOGY IN POPULAR EDUCATION

George A. Thiel
University of Minnesota

Many geologists feel that the public does not understand what geology is, what it does, and what more it can do for the average citizen. Unfortunately many members of our profession are utterly indifferent to public interest and to securing greater recognition and appreciation of the value of earth science in popular education. This attitude makes the problem all the more difficult, for certainly the impetus for more and better earth science in popular education, and in the secondary schools in particular, must be generated within our own ranks.

The writer has stated on many occasions that the reason for his urging the teaching of earth science in the secondary schools is not to attract more students into the departments of geology in the colleges and universities, but rather to acquaint more citizens with the basic concepts of earth science. When this has been accomplished there will follow an improvement of the status of geology in the minds of the public, of boards of education, and of legislators.

The dearth of knowledge of what geology has to offer is illustrated in a list of occupations compiled recently by a state board of education and distributed to the vocational counselors in the high schools of that state. The list contained nearly three hundred occupations but the term metallurgist was the only one listed that was even remotely related to earth sciences. No mention was made of geology nor of the scores of occupations for which students trained in geology are eligible--not even mining engineering. It is the more incredible when one realizes that the state referred to is famous for its mineral industry.

In most states the board of education or the commissioner of education approves the curricula of the various teacher-training institutions. From the evidence at hand, perhaps it is time to re-examine and re-evaluate these curricula in the light of present trends in general education. The curriculum for the education of science teachers in many training institutions is unrealistic. Too often prospective teachers of science for the lower schools are not trained in broad areas that will enable them to do a good job teaching several sciences or "general science" in their early years of teaching in small high schools. It should also be pointed out that conventional science courses offered to teachers provide good background for the traditional high school courses but do not provide adequately for the newer courses that are emerging to meet the needs of students who will not enter college. Much of the present teacher training fails to give breadth of understanding or comprehension of the interrelationships existing between the many broad aspects of the natural sciences. An understanding of these interrelationships is essential for teachers in the secondary schools where they must, at best, teach in broad areas.

Most of the teachers colleges have not shown great resourcefulness or utilized much imagination in the design of curricula appropriate for the training of teachers of general education. It may be impossible to put anything more into a curriculum that is already overcrowded, but perhaps some overspecialized courses could be made optional for the prospective general science teacher in order to make room for at least one basic course in geology.

A preliminary survey conducted by the writer several years ago revealed the amazing fact that no more than two percent of the highschool science teachers in the upper Midwest had received systematic training in earth sciences. It is obvious that teachers who have not had an opportunity to come in contact with geologic science will not be charged

with much enthusiasm for the subject when it is encountered in the general science texts they use when teaching in high school.

There are two avenues of approach in an attempt to solve the present dilemma and each demands tact and patience. One is to integrate earth science subject matter with studies in conservation. The other, which will be the more difficult, is to urge the inclusion of geologic courses in the natural science curricula of the teacher training institutions. The growing interest in conservation at both the state and national levels may become a factor in inducing the professional educator to modify the curriculum of the prospective natural science teacher. Many school administrators now recognize the teaching of science and conservation in the elementary and secondary schools as a matter of major importance. In some states this recognition was brought about through the pressure of legal requirements. In others it has developed as a natural product of the present scientific age or through a realization of the importance of conservation. In either case, the courses in conservation offer channels through which some geologic subject matter can be presented to our future citizens.

A number of states have departments of conservation that sponsor educational programs by radio. This is another channel through which geologic subject matter can be carried to the public. The script writer for the program may welcome ideas pertaining to earth science that could be incorporated into his script.

Still another method is by means of tape recordings such as are now available from the educational divisions of a number of state departments of conservation. Tape libraries have been established through which tapes are loaned free of charge to the primary and secondary schools of the state. Most conservationists realize that geologic information is basic to an appreciation of the broad principles

of conservation and many would be willing to include in their libraries recordings featuring subject matter that would lead to a better understanding of the earth's physical features.

Most professional geologists do not have contacts with high-level secondary school administrators, but many are associated with state geological surveys that are under the administration of the state department of conservation. Some geologists in such positions are already doing an outstanding job and others are reminded of their responsibility and are urged to become more aware of the service they can render their profession.

A concluding appeal is made to every member of the profession. All geologists who have faith in the value of the principles and concepts of earth science can disseminate their enthusiasm through personal contacts with other citizens and if all take advantage of this personal opportunity, greater appreciation of our science will result.

CHANGING REQUIREMENTS IN CHEMISTRY, PHYSICS, AND MATHEMATICS FOR GEOLOGY MAJORS[1]

H. R. Gault
Lehigh University

That the geological sciences are becoming more quantitative and that chemistry, physics, and mathematics are being applied more and more to geological problems is very evident as one goes through present-day literature. There is, also, a trend toward research teams in which the geologist must not only be able to understand the chemist and physicist, but must also be able to translate geology for them in their terms.

The Committee on Geology of the Mineral Industry Education Division, American Institute of Mining Engineers, felt that it would be of interest to determine whether the increasing need for training in chemistry, physics, and mathematics was reflected by changing graduation requirements for the B.A. or B.S. degree in geology in the past fifteen years. Accordingly, the graduation requirements in these three fields were obtained from nineteen universities, colleges, and technical schools. Table 1 shows the geographic distribution, character, financial basis, and size of the institutions surveyed.

Table 2 summarizes the data obtained. Only required courses are shown. In some cases it was difficult to ascertain definitely the requirements--or there were two sets of requirements. In such cases

---

[1]Read at the first annual meeting of the Eastern Section, Association of Geology Teachers, April, 1951. This paper was prepared as part of a study made by the Committee on Geology, Mineral Industry Education Division, American Institute of Mining Engineers, and was summarized in the unpublished report of the committee.

minimum requirements were used. Requirements are expressed in terms of years of study in each field.

TABLE 1. Schools Surveyed

Geographic distribution		University	College	Technical	State	Private	Large*	Small
East	5	3	2			5	3	2
South	2	2			1	1	2	
Midwest	6	5	1		4	2	4	2
West	2	1		1	2		1	1
Southwest	2	2			2		1	1
Pacific Coast	2	1	1		1	1	1	1

*Enrollment over 3500 students

The average number of year courses required in the three fields at five year intervals is shown in Table 3. Obviously a survey of only nineteen schools cannot give an accurate and complete picture, but it is believed that the schools sampled should reflect the trend.

It is immediately apparent that there has been a steady and gradual increase in requirements despite the wide variations among individual institutions. If one took into account the recommended courses the increase would possibly be even more pronounced. Fortunately, most of the schools with requirements below the average recommend course work which brings them up to or above the average.

TABLE 3

Average Requirements at Five-Year Intervals

	1935	1940	1945	1950
Chemistry	.92	.97	1.10	1.26
Physics	.47	.55	.66	.71
Mathematics	.61	.71	.81	.92
Total	2.00	2.23	2.57	2.89

Chemistry and mathematics show the greatest increase. Whether it is required or recommended, almost all geologists take one year of chemistry. Physical chemistry is recommended with increasing frequency. Except in engineering or technical schools, or for geophysics options, the physics requirement is generally one year only. Mathematics through trigonometry and analytical geometry is becoming a standard requirement. Because of strong recommendations, calculus is being taken by many.

This trend is considered a healthy one for geological training. The writer does not feel that it should be regarded as a sign of overemphasis on professional training even in liberal arts colleges. Chemistry, physics, and mathematics are basic sciences and one year of each should be a part of any liberal education. No question of overemphasis on professional training arises until a second year of chemistry and mathematics are added. Generally even two years' work in these fields can be considered as part of the "minor" required in many liberal arts colleges. It has been the writer's experience that the student who is well grounded in these fundamental collateral disciplines is better fitted for geological work than the student who slighted them to get additional geology courses.

TABLE 2. Requirements by Schools at Five-Year Intervals

School	1935			1940			1945			1950			Remarks
	Chem.	Phys.	Math.	Chem.	Phys.	Math.	Chem.	Phys.	Math.	Chem.	Phys.	Math.	
1.	1	-	1	1	-	-	1	-	1	1½	1	1½	Honors and grad. school candidates must take additional work.
2.	1	-	-	1	-	-	1	-	-	1	-	-	From 1945 on additional courses in biol., math., and phys. recommended.
3.	-	-	-	-	-	-	½	-	-	½	-	-	Elementary courses in math. and phys. recommended.
4.	-	-	-	-	-	-	-	-	-	-	-	-	Analytical chem., 2 yrs. phys., and math. recommended.
5.	-	-	-	-	-	-	2	1	1	2	1	1	Calculus recommended.
6.	1	-	-	1	-	-	1	-	-	1	1	1	Calculus and physical chem. required in addition for grad. school candidates in 1950.
7.	?	?	?	1	1	½	1	1	½	1	1	½	Additional math. required in 1950 for B.S. in engineering.
8.	(1)(½)		-	(1)(½)		-	(1)(½)		-	(1)(½)		-	Stated requirements: 20 hrs. in science, math., mining, civil engineering, econ., or geography.

9.	-	(1½)	-	-	(1½)	-	-	(1½)	-	-	(1½)	-	Choice of botany, zoology, or phys. Calculus and physical chem. recommended.
10.	-	-	-	-	-	-	-	-	-	1	-	-	8 hrs. of phys. and trig. strongly recommended.
11.	2	1	1½	2	1	1½	2	1	1½	2	1	1½	Math. through calculus.
12.	1	1	1	1	1	1	1	1	1	1	1	1	Calculus, analyt., and physical chem. recommended.
13.	2½	1½	2	2½	1½	2	2½	1½	2	2½	1½	2	Requirements as indicated.
14.				1	1	2	1	1	2	1	1	2	Math. through calculus. Geology not offered in 1935.
15.	1	1	½	1	1	½	1	1	½	½	1	1	Requirements as indicated.
16.	1	-	-	1	-	-	1	-	-	1	-	-	Requirements as indicated.
17.	2	1	1	2	1	1	2	1	1	2	1	1	Paleo. and stratig. majors may omit phys., and take only ½ yr. math. and 1 yr. chem.
18.	1	1	2	1	1	2	1	1	2	1	1	2	Requirements as indicated.
19.	1	1	2	1	1	2	1	1	2	1	1	2	Math. through calculus.

GEOLOGY IN GENERAL EDUCATION COURSES: AN OBSERVER'S REPORT

James Brice
Washington University

The Fund for the Advancement of Education, a division of the Ford Foundation, generously granted me a fellowship for the academic year 1951-52 in order that I might study the teaching of geology in college programs for general education. As part of this project, I spent the fall semester at Harvard studying the extensive general education program which has just become an integral part of their curriculum. Although geological material is little used in any of the five natural science courses, I nevertheless felt that the philosophy and techniques developed for the teaching of other aspects of physical science could profitably be applied to the teaching of geology. My study of the program consisted of auditing most of the lectures, attending some discussion sections, and talking with lecturers and teaching fellows. Of the group of Ford and Carnegie fellows at Harvard from other colleges, some had considerable experience in teaching general education science courses in programs at their own colleges, and I profited by discussion with them. As a geology teacher, I have set myself two questions, to which I shall suggest partial answers here: What is the role of geology in general education? By what means may geology for general education be most effectively taught?

A broad term like general education cannot, of course, be rigidly defined, nor can its goals be unqualifiedly set forth. Most advocates agree, however, that general education science courses, as contrasted with conventional science courses, do not attempt systematic factual coverage of a single segment of physical science, but rather seek to impart a thorough understanding of a few basic concepts from the whole field of physical science. The main

goal is education, not for competence in some occupation, but rather for development into responsible human beings and citizens. Other frequently expressed goals include an understanding of science and of how scientists work, a realization of the limitations of science, and an awareness of the relations between science and society. I feel that general education at Harvard is successful, and that much can be learned from the techniques and philosophy of the program. Most of the students seem to approve of general education, although some do not like being required to take courses in fields outside their own interests.

The Role of Geology

Geology alone cannot fulfill the requirements of a general education science course, but there are distinct advantages to the presentation of natural science from the geologist's point of view. Much of geology is based upon concepts of chemistry and physics which many college freshmen have grasped imperfectly or not at all. The geology teacher reviews and gives further meaning to these principles. He deals with tangible, familiar materials--minerals, landscape, products of rock weathering--which serve to demonstrate at the same time both geologic principles and the more abstract principles of chemistry and physics. The natural interest of students in geologic materials can be used to advantage. For example, most students are interested in gemstones. Demonstrations on these can be devised to illustrate at the same time properties of light and properties of minerals.

Any general education course is in fact presented from the professor's particular point of view, whether or not he admits it. A physicist presents natural science from the physical point of view; a chemist presents it from the chemical point of view; and so on. Some general education courses are taught successfully by a team of lecturers, each dealing with his own specialty, but the feeling is pretty general that a single qualified lecturer is desirable.

The extent to which geology is a part of general education programs over the nation is an interesting question, but an exact answer is not easy to find. Summaries of content of general education courses commonly list geology, without indicating to what extent it is taught. Of the twenty-two colleges which submitted a resume of their programs to Stickler (1951), nine evidently require courses in physical science which contain some geology. Geology is briefly presented in two of the Harvard courses, and omitted in two. Two physical science textbooks in general use--Krauskopf (1948) and Cheronis (1950)--both contain substantial portions of geology, which are doubtless omitted or reduced by some users. I believe that in most general education programs geology is either omitted altogether or presented descriptively in small measure along with other aspects of physical science, serving commonly as a relief from the more abstract and difficult concepts of chemistry and physics.

The proper role of geology in a natural science course is not to precede a selection of chemical and physical concepts as a sort of academic warm-up, nor to be inserted between these concepts as a breather, nor yet to follow in descriptive fashion, leaving restful images of rocks and scenery in the mind of the student. Geology should follow the presentation of the concepts on which it is based, but it should be presented analytically rather than descriptively. The textbook by Garrels (1951) is considered a refreshing example of the analytical approach to elementary geology. Geology should be integrated with principles of chemistry and physics at every opportunity, demonstrating their function in the explanation of natural processes. Such topics as weathering, radioactive age determinations, geysers, crystal structure, and volcanism all recall chemical and physical knowledge. The physical science textbook by Krauskopf (1948) has an admirable chapter on silicon compounds, integrating mineralogy with previously discussed chemical principles.

Selection and integration of geologic concepts for presentation in the general science course is an important problem. It is neither possible nor desirable to cover all of the information in a conventional textbook of elementary geology. When a geologist is asked to suggest the really basic concepts of geology, he usually mentions uniformitarianism, some principles of stratigraphy, perhaps the erosion cycle; then he looks puzzled and searches his mind for further suggestions, wondering why he can't summarize as concepts the bulk of geologic knowledge. Geology, not being a basic science, naturally contains few neatly packaged subjects such as Newtonian mechanics, the kinetic theory, or radiation, which the chemist or physicist may mention readily enough. Furthermore, the subject matter of geology is usually thought of as a group of arbitrarily delimited topics, such as "work of the wind", "sedimentary rocks", or "volcanism". It is difficult to choose from such topics, because none are really basic. Moreover, no combination of a few gives a coherent picture of geology. Some scheme is needed whereby all of these topics can be integrated, giving the essentially historical theme of geology first consideration.

One such scheme may be suggested here. The primary units of crustal architecture are the continents and ocean basins. The continents themselves, from the standpoint of both structure and physiography, have only two fundamental architectural parts: the mobile belts, expressed as mountain chains, and the rigid blocks, expressed as plains and plateaus. Upon these premises, an outline such as the following can be formulated: The origin and history of the earth's primary relief features--continents and ocean basins.

The origin and history of mountain chains.
Observations: Geographic distribution of mountain chains; scenery of different mountains; geologic structure of mountains; rocks types and stratigraphic thicknesses characteristic of mountain chains as contrasted with plains and plateaus; etc.

Inferences: Geosynclinal theory; orogenic cycle; effect of different agents of gradation; Davisian erosion cycle; etc.
The origin and history of plains and plateaus.

By this scheme, the evolution and meaning of scenery, which is of first importance to the general student, can be dealt with thoroughly and directly. Of course it will have to be preceded by an elementary consideration of earth materials and levelling processes, but the main discussion of rocks would be in connection with the environments in which they are formed; the main discussion of the agents of gradation would be in connection with the scenery on which they operate.

Means for Effective Teaching

During the evolution of existing courses in natural science at various colleges, some unconventional techniques and approaches have been developed and found to be effective. These include the "case history" method in use for Natural Science 4 at Harvard; the "problems in natural science" method as used at Colgate; and the greater use, in general, of the history of science. (For an authoritative discussion of the use of the history of science, see Cohen and Watson, 1952, pp. 60-130.) The historical approach has undoubted virtues, offering as it does a means of stimulating interest, of demonstrating how scientists work, and of illustrating the mutual relations of science and society. It is my own feeling that these points can be adequately made with one or two case histories, or by the historical treatment of one or two topics, and that the exclusive or dominant use of historical material becomes repetitious and of diminished effectiveness. Unfortunately the time required for discussion of the history of science greatly restricts the time available for discussion of modern scientific knowledge, and many instructors will feel that modern knowledge has its own indispensable values.

The selection and effective presentation of topics for geology laboratory or discussion sections is a

frustrating problem, for which the techniques used in other natural sciences offer little assistance. Demonstrations are used effectively for many principles of chemistry and physics, but demonstrations of geologic principles, if possible at all, are clumsy and difficult, perhaps also misleading. Field trips, although highly desirable, are obviously not always feasible. From my own experience with geology laboratories, and from discussions with students from different colleges, I have concluded that most students do not find the conventional exercises stimulating or even very comprehensible. There are simply rocks and minerals to be memorized and forgotten, the usual struggle with contour lines and the interpretation of topographic maps, and the complicated geologic maps which few students really understand. For the future geologist these things are necessary and interesting, but it is doubtful if they represent the best use of the general student's time. The vital elements which make geology interesting elude us: The grandeur of scenery cannot be brought indoors, and the imposing vistas of time and change are beyond our powers to exhibit. The rocks and minerals, torn from their native habitat, lie naked and nearly meaningless on the laboratory tables, and the topographic map does not convey to the beginner an impression of the scenery it represents.

There is no ideal solution to the laboratory problem, but the best compromise seems to lie in the extensive use of photographs, lantern slides, and relief models. Clear and significant lantern slides can be shown to the students, and problems posed regarding them--problems which will test the powers of observation and reasoning ability of the student. For example, as part of an exercise on igneous rocks, a photograph or diagram of intersecting dikes could be shown, and the students asked to work out the order of intrusion. For an exercise on agents of gradation, photographs of different valleys could be shown, and the students asked to point out evidences of the action of streams and other agents in detail. Photographs of stratigraphic sections, accompanied by specimens from each rock unit, could lead to profitable

discussions of interpretation.

Geology unquestionably has an important contribution to make to general education. Geology teachers have an obligation, both to their profession and to their country, to see that this contribution is made. The conventional teaching methods are perhaps suitable for professional training, but it is questionable that they represent the best we can do for the citizen. Consultants on general education say that professors, when asked to revise their courses to accomplish the goals of general education, commonly assert that no revision is necessary, that these have always been among their goals. Experience has shown, however, that revision can bring improvement.

References Cited

Cheronis, N. D., J. B. Parsons, and C. E. Ronneberg The Study of the Physical World, Houghton Mifflin Company (1950).

Cohen, I., and F. G. Watson General Education in Science, Harvard University Press (1952).

Garrels, Robert M. A Textbook of Geology, Harper and Brothers (1951).

Krauskopf, Konrad Fundamentals of Physical Science, McGraw-Hill (1948).

Stickler, W. H., (editor) Organization and Administration of General Education, Wm. C. Brown Co. (1951).

GEOLOGY IN THE PHYSICAL SCIENCES COURSE IN THE COLLEGE OF THE UNIVERSITY OF CHICAGO[1]

Lou Williams Page
Washington, D. C.

Geology was taught in the Physical Sciences course in the College of the University of Chicago during nineteen of the twenty years that the course was given. The time allotment, content, aims, philosophy, and teaching personnel underwent many changes during this period, and the present discussion is limited to the geology presentation from 1946 through the summer of 1950, the last time that geology was a part of the course.

During this period a student who entered the College at the thirteenth grade (third year of the College) had to pass fifteen stipulated comprehensive examinations[2] (unless excused from one or more on the basis of entrance placement tests) in order to receive his

---

[1]Except for slight revisions, chiefly in the opening paragraphs, the paper as it appears here was read at the annual meeting of the Association of Geology Teachers at Hanover College, Hanover, Indiana, in April, 1948.

[2]There were fourteen six-hour comprehensive examinations--two in Humanities, three in Social Sciences, two in English, and one in each of the following: Writing and Criticism; Mathematics; History of Western Civilization; Organization, Integration, and Interpretation of Knowledge; Biological Sciences; Physical Sciences; and a foreign language. The fifteenth was a two-hour examination on Language I.

A.B. degree. To prepare the student for taking the comprehensive examinations various courses were given, among them that in Physical Sciences, which extended over three quarters.

Some 700 students enrolled in Physical Sciences were taught by a staff of about twelve instructors who had specialized in different branches of the physical sciences. During the period under discussion the students were divided into four lecture sections, each of which met twice a week, and also into some twenty-five discussion sections of fifteen to thirty-five students each, which also met twice a week. Attendance was compulsory at neither. Lectures were given by the staff members particularly trained in the field being discussed, and in addition each staff member led from one to four discussion section groups throughout the year.

Seven or eight lecture periods and the same number of discussion section meetings, extending over about a month, were devoted to geology. A field trip was held, weather permitting, and the Encyclopaedia Britannica films on geology were shown. Kodachrome slides were used in the lectures. In the discussion sections the work centered chiefly around the questions on geology in the course Question Book. Assigned reading included the seventy-seven pages on geology in the Syllabus, where the treatment closely followed the lecture presentation given below; selections from the works of Playfair, Lyell, Davis, Agassiz, and others, which appeared in the course Readings Book; and specific selections from Croneis and Krumbein's Down to Earth, and the Yale texts, Outlines of Physical Geology and Outlines of Historical Geology.

The aim of the College is to give the student a liberal education, not to prepare him for specialization in any particular field, and the Physical Sciences course was tailored to fit this objective. The aims of the course were (1) to help the student to build a picture of the physical universe as conceived by modern science, and (2) to help him to

understand the methods of science and to train him in the use of these methods. The course consisted of an integration of the major ideas from astronomy, geology, physics, and chemistry. These ideas were subjected to critical analysis.

The geology included in the course was selected for the contribution it made to a picture of the world and to understanding the methods of science. The major problems taken up were (1) the evolution of landscape, (2) agents, products and processes of geology, (3) evidence for the reconstruction of earth's history, and (4) peculiarities of geology as a science. These latter were considered to be, chiefly: its necessary emphasis on field studies, its introduction of the idea of evidence for a cycle in the detection of various stages of the supposed cycle, and its problems of scale and extrapolation.

This mode of presentation of geology was developed chiefly along lines outlined by Theodore A. Ashford, now of St. Louis University, with the assistance of Robert M. Garrels, now of Northwestern University. Its details were developed and it was presented from 1946 to 1949 by the present writer, with the help of Christina L. Balk and of graduate students in geology at the University of Chicago.

The presentation began with a brief discussion of man's early ideas about earth features: they were long considered catastrophic or miraculous in origin, static, and of a common age. Then Hutton's assumption of a naturalistic origin of earth features was introduced by showing that it was a delayed but expectable outgrowth of the Copernican Revolution and the contributions of Galileo and Newton. Features observed by Hutton which gave him the idea were presented. The roles which induction and generalization played in its development were pointed out. Hutton's own realization of the far-reaching significance of the principle was indicated, and we traced its subsequent strengthening and growth in the hands of Playfair, Lyell, and later geologists.

In common with the assumptions which lie at the foundations of all scientific theories, the validity of uniformitarianism can be indicated only by its fruits: how well observed facts fit the logical deductions from this basic assumption. With this in mind we set the two opposing views, catastrophism and uniformitarianism, in conflict on a specific problem: the formation of a river valley. The uniformitarian view suggests that the valley was made by the river that flows in it, for the erosional work of running water is the "present process" in this case. We pointed out that uniformitarianism must explain all the features of a valley if it is to be accepted. The Grand Canyon of the Colorado River was taken as an example of a valley. We demonstrated that the river is actually carrying away material, that there is a mechanism for getting the material to the river in a form it can handle (weathering and slope wash), likewise a mechanism for actual deepening of the valley, and that the material now being taken from the valley is being deposited at a known site at a known rate. We showed that the observed cross-section of the valley is the appropriate result of these processes. Thus the river was shown to be actually enlarging and changing its valley. But is it capable of developing it "from scratch"? Rough calculations were presented showing that, given seven million years or so, the river could have cut this entire valley. Let me point out the methodology involved here. We were demonstrating the correspondence between theory and observation--between the ideal and the actual. We were demonstrating also that certain (valley) features found together were products of orderly process, not of chance.

Next we delved further into the question: "Is the valley actually changing?" Our theory demanded that it should be, yet any changes observed in historic time are too small to be noticed. This served as an introduction to the observed headward growth of streams, and the idea that the mouthward portions of streams should, therefore, be successively "older" in the sense that the stream has worked longer on them

and changed them most. William Morris Davis' concept of the development of an ideal river of simple history was introduced at this point and his definition of youth, maturity, and old age as river conditions. This was an example of a postulate system in science. A study of actual rivers in the light of Davis's ideas gave additional strength to the original theory: that rivers make their own valleys.

Then we looked at a wider consequence: If rivers make and systematically change their own valleys, the regions through which they flow--which they and their tributaries are eroding--should also systematically change. The landscape itself should be a dynamic thing. It should, in a manner comparable to that of a single valley, go through successive stages of development. By study of regions in various stages of the supposed cycle we should be able to picture the successive stages of the landscape cycle, with the peneplain as the final stage. Then it was pointed out that if this is true, we have a clue toward reading the history of the earth. It will be read in the succession of changes that its landscapes, through the ages, have gone through, and in the succession of deposits which the rivers of these landscapes have brought to the seas.

In the case of the stream cycle the validity of uniformitarianism was demonstrated in some detail. It was pointed out, however, that if we are to accept this basic principle, we must be able to show that every feature of the earth's present landscape can be explained in terms of presently-operating processes. In less detail than in the case of river valleys, some other examples were introduced to show that these too could be explained by uniformitarianism. Our principal examples were shoreline features and features resulting from the recent glacial epoch.

At this point we paused to look at the logical consequence of all these surface processes. The land should be reduced to a featureless peneplain at sea level or below, or to a marine bench. Why hasn't

it been? One possible explanation, which we suggested, is that there has not yet been time enough to bring all erosional cycles to completion. Another is that there are tendencies opposing the degradation of the land. Since our students were not at this point prepared to judge the first assumption, we examined the second. Are there any processes which build up the land? Volcanoes immediately suggested themselves --plus lava flows and intrusions. These were shown to be inadequate to keep up with erosional degradation. But they suggested a mobility of the solid crust that had not occurred to us before. Perhaps the solid crust can rise to oppose the degradational tendency. Is there any evidence? Back we went to the Grand Canyon and looked at the rocks there. We found them very much like sediments accumulating in the seas today, and we found that they contained fossil remains of creatures which resemble marine forms of today. Uniformitarianism suggests that these rocks were laid down in the sea. If so, strata now at the rim of the Grand Canyon at elevation 7000 feet were once below sea level. Uplift must have occurred.

We pointed out that rocks in many parts of the world show marine characteristics. The continents--or large parts of them--appear to have risen with respect to sea level. Other evidence was presented in the form of rejuvenated streams, shorelines of emergence, and raised marine benches. Then we brought up the question: Is such uplift compatible with uniformatarianism? We showed that it is. Such movements are actually going on at present. We gave many examples of earth movements within historic times: earthquakes, the slowly rising coast of Scandinavia, etc. We pointed out that we were not yet ready at this stage in the course to examine the mechanism of uplift. Other evidence that earth's crust is mobile, and therefore capable of uplift, was introduced: faults, folds and metamorphic rocks.

Having established the fact of diastrophism, we made the students see that the problem of reconstructing the history of the Grand Canyon was now complicated

enormously. We showed that the present valley is but an ephemeral feature, the product of the present geological moment, not of all geological time. Events went on before the canyon cutting, and we showed that these events are recorded in the rock strata--marine beds indicating when the sea was over the area, other beds recording deposition on land. There was the evidence before us, and we were pushed willy-nilly into a more extended study of the history of the whole Colorado Plateau, and hence of the entire earth.

But this, we noted, is a tremendous undertaking. What specific principles are there, we asked, to guide us in interpreting the rock record? The principle of superposition, the laws of intrusion and folding, and the idea of unconformities as "fossilized landscapes" were introduced, and in terms of them an event history of the Grand Canyon area was worked out.

This led us to the problem: How were we going to tie this history to that of the rest of the world? What was going on in other areas while these rocks were being deposited, and these unconformities eroded? We then presented the development of the principle of organic correlation, beginning with the work of William Smith. Examples were shown. We correlated the rock section in the Grand Canyon area with that of Chicago and a part of the Appalachians, using symbols to indicate index fossils. These three sections were tied together into a composite section, in the same way that Smith tied together the cliff, quarry wall, and canal sections: by means of fossils --thus building up a more complete story than any one section told, and also "erasing" one or more unconformities by finding areas where a sedimentary record bridged the interval. We showed that what we had done with these three areas could be done with 100,000 such areas, and that when this was done, the result would be the "geologic column".

We looked at the column as it is now known noting that as we go up the column the forms of life become more and more like modern forms--additional evidence for evolution, which we had already briefly discussed

in connection with the principle of organic correlation. We also noted that many unconformities had been erased, but that four at least were left, there being almost no sediments bridging the gap they represent. The division into eras by means of these widespread unconformities, and into periods by means of others less widespread was shown to be more than a convenience; it has a natural relationship to the causes of diastrophism. We pointed out that there seems to be a rough synchronization of major periods of diastrophism in different parts of the earth's crust.

Next we pointed out what the geologist does with the column. When he goes into a new area he fits the local section into the column by a study of its index fossils and finds what eras and periods are represented. By a study of the rock types he gets a fair idea of conditions in the area at each of these times. We showed how paleogeographic maps of large areas are worked out and how a succession of these maps gives an overall picture of the earth's history.

One half-hour lecture covered briefly some known highlights of earth history. Next we pointed out that some of the events recorded in earth history are of enormous magnitude, and that if we are to explain them from the uniformitarian viewpoint they must have been brought about by slow and gradual changes. This led to the question of how long a time these events represent: How old are earth's oldest rocks? After a discussion of various unsatisfactory methods previously employed to find an answer to this question, we showed how a new approach was made possible by the discovery of radioactivity. We pointed out that the millions of years indicated by lead-uranium measurements allow enough time for the recorded events of geologic time to have taken place at a uniformitarian rate. We also pointed out that this method enables us to determine directly, in years, the age of a rock mass, and the duration in years of the various eras and periods. We showed how

the enormous minimum age of the earth was arrived at, and pointed out that radioactive age determinations vindicate the geologic column as set up on purely geologic reasoning.

As a last topic we discussed the problem of the cause and mechanism of diastrophism, using all the facts so far learned that might have bearing on it. Here we found an example of a case where no theory so far proposed seems to be entirely satisfactory; no one theory appears to be able to explain all the facts. We made the students see that not all of the problems of geology are solved and that it is a dynamic and growing science.

Finally we showed how geology joins forces with astronomy (which was presented immediately before) to consider the mode of origin of the solar system.

Although this was the end of the "formal" presentation of geology in the course, considerably more on the subject was given from time to time during the remainder of the year. For instance, radioactive methods for the determination of the age of rocks were studied in more detail in connection with the section on nuclear disintegration; rocks and minerals were used as examples of mixtures and compounds in the chemistry portion of the course; seismic waves and the interior of the earth were considered in connection with wave phenomena in the physics section; and the mass and density of the earth entered into the study of gravitation.

HOLDING STUDENT INTEREST IN HISTORICAL GEOLOGY[1]

Percival Robertson
The Principia

I still have a vivid recollection of the first field trip I ever conducted for a group of beginning students in historical geology, although it occurred many years ago. I had taken them a few miles out into the country and had placed them on a reasonably fossiliferous outcrop. (I think it was the Decorah formation.) After they had been working for a considerably longer time than I thought necessary, I remarked in a loud voice, "Class is over for the day. Let's get aboard our cars," and walked back to my car--quite alone. I thought perhaps they had not heard me, and so I walked back again and repeated, "Class is over." Still no one left the outcrop. It was the first time in my life that I had ever announced the conclusion of a class period and no one was headed for the door. I waited and began to do some computing of the amount of time it would take us to get home, and then said, "If we don't get going in ten minutes we will be late for supper." Even after that dire threat, many of them were reluctant to leave the outcrop.

What is the fascination that fossils have for students? It is difficult to analyze but, whatever it is, I have based my courses in historical geology upon it. The greatest interest lies in the study of fossils in the field, but even if I were located where it was impossible to study fossils in the field, I still think that fossils should be the central theme of historical geology--not pictures of fossils, not drawings of fossils, not lantern slides

---

[1]Paper read before the annual meeting of the Midwest Section of the Association of Geology Teachers, DePauw University, Greencastle, Indiana, April, 1951.

of fossils, but the little "bugs" themselves.

Another principle which guides me in my teaching of historical geology is my belief that to hold the student's interest, the teacher must provide him with information and methods of thinking which he sees will be valuable. I do not mean by this that the student must immediately see the reason for every single topic to which he is introduced. I am not sufficiently sold on the now somewhat archaic idea of "progressive education" to believe that. But I do think that it is desirable in teaching any course to give the student an abundance of material of the sort which he personally is likely to be able to use and a modicum of that which is useful only to specialists in the field. I, therefore, keep constantly in mind that the large majority of my students will not continue geology beyond a first course. The main objective for such students should be to help them to understand the world in which they are living. If, when they get through the course, they can interpret the broad, conspicuous features of the landscape around them--if they can recognize as old friends some of the larger fossils which they are likely to encounter in the rocks and have some grasp of what these fossils tell us about the conditions that existed at the time they were buried--, that to me is far more important than that they should know the specific names of a lot of micro-fossils, or how to interpret an isopach map, or a lot of other knowledge that the trained geologist needs, but for which the average layman finds very little, if any, use.

In my course I have about thirty periods for lectures, recitations, and quizzes; and twenty three-hour periods for studying maps and fossils and for field work. We ordinarily have five or six field exercises, two or three of which are combined in a two-day trip. As noted above fossils, the evidence of once living things, are the central interest-theme of the course.

How should students be introduced to fossils?

First, I try at the very start to inculcate the idea that we are not studying things which belong entirely to the past. I point out that the ideas of Washington and Lincoln, of Isaiah and Shakespeare, are as alive today as when these men walked the earth. After all, fossils tell a story of the triumphs and failures of the ancestors of creatures alive today.

After the right mental approach to the study of fossils is reasonably well established, I turn to the technique of getting the students sufficiently well acquainted with some of the common varieties so that they can recognize them and call them by name. Students should learn to call fossils by name, though I can see no useful purpose in having them memorize the names of numerous species which most of them will probably never encounter again.

The method of studying organisms made famous by Agassiz--that of drawing the animal until one has seen and recorded every essential detail--is doubtless the most thorough method of getting acquainted with fossils. But after having once tried this method in historical geology laboratory, I have abandoned it because it tends to dull enthusiasm and thus discourages the very thing I am striving for. I may add that I have tried the opposite extreme of having students study pictures in the book and lantern slides, but this method was not a success either. It did not require close enough application on the student's part.

I have prepared a manual[2] in which, in addition to five exercises dealing with interpretation of geologic maps, there are ten others which introduce the student to the commoner fossils. At the beginning of each exercise, there are a few sentences

---

[2] To be published in the summer of 1952 by the Burgess Publishing Co., 426 S. 6th St., Minneapolis 15.

which epitomize what has been brought out in lectures. Then follow several pages of simple descriptions of specific fossils followed by blank spaces. Then there are several pages of pictures of fossils, arranged at random. The student must select the picture that fits each description, paste it in the proper blank, and thus produce an illustrated manual. This takes far more attention than simply looking at a labeled drawing.

I can make the procedure clearer by describing the first laboratory exercise, which deals with trilobites. After a few general statements about trilobites--their structure, range, importance as guide fossils, and so forth--there is a description of the various hard parts of a typical trilobite. Among the pages of illustrations there is a picture of a typical trilobite with the parts numbered. The student cuts this out and pastes it in a blank space opposite the foregoing description. He then identifies and labels the various parts: thorax, cephalon, pygidium, and so forth. The student now proceeds to a series of descriptions of various common types. From the pages of pictures he has to find the picture that corresponds best to the description given and paste it in its appropriate place. While the descriptions attempt to be accurate, they are not couched in elaborately scientific jargon. The vocabulary is confined to names of some nine parts learned in the study of the first picture. The descriptions include the geologic range of the fossils. In some instances they include the species name and in some instances they do not.

The trilobites to be studied are selected on one of these two bases: either they are likely to be encountered by the student on field trips, or else they are important guide fossils referred to in the lectures.

The first laboratory exercise takes only a short time to complete. The second exercise deals in like manner with some of the commoner fossils in the

bryozoan, porifer, and coelenterate phyla. The selection made is on the same bases as in the case of trilobites. At the end of the second exercise and all subsequent ones, there is another feature added. Each student is given a tray containing a dozen fossils which he is expected to identify. In every case he must tell the phylum; usually he can tell the class; and in some instances he may be able to identify the genus, or even the species. The student is warned not to try to carry his identification farther than is justified by the pictures he has available.

This constitutes the second step in getting acquainted with fossils. Every succeeding exercise may include fossils studied previously. The reason we do not give the students a tray of fossils at the end of the first exercise is that it is not practical for them to identify a dozen different trilobites.

After the student has had a sufficient number of exercises to introduce him to the more common and abundant fossils, he is taken to a nearby outcrop and is asked to find some fossils and to bring them back to the laboratory and identify them as far as his somewhat limited knowledge will permit. He is encouraged to use illustrations in his textbook, but since the laboratory manual has purposely been arranged to cover the fossils he is most likely to encounter, the manual is his principal source of information. It is my experience that when the student has first learned to identify an idealized picture of a fossil, and then the selected specimens which he finds in his laboratory trays, he is able to get a surprising amount of information from the poorer material he finds in the rocks.

After a couple of field trips in which the emphasis is on finding and identifying fossils, the student is put on an outcrop in which there are rather abundant specimens of some guide fossil, and he will be expected to identify the age of the rock as far as the guide fossil will enable him. Toward the end of the

course the student will take either two one-day trips, or usually a two-day trip which will carry him farther from his home base, expand his paleontologic horizon, and confront him with problems of correlation. Perhaps the most important concept the student gets through this method of study is that geology deals with actual things as they exist in nature and is not just a description written in a book. I think that to a large number of students there is very little difference between the historical geology that they read in the textbook and an imaginary story or play. But when the student finds that what he is reading about is <u>real</u> and that he can observe it himself in the world about him, he has made a discovery which I think highly valuable to his intellectual maturity. One young lady most naively remarked after her first field trip, "I read about these things in my text, but I didn't have any idea you could just go out and find them."

I referred earlier to the fact that there are five exercises in our manual dealing with the interpretation of geological maps. These are left in because we feel that it is a necessary part of the student's education in geology to see and interpret such maps. We try to introduce one idea at a time. After a preliminary exercise on the symbolism used in geologic maps, the student is introduced to horizontal structures, and in later exercises to inclined or folded structures, faults, and igneous structures.

Maps have to do primarily with the physical aspects of historical geology. While a certain amount of study of former seaways, mountain ranges, etc., is admittedly essential, the great interest for me lies in the unfolding drama of animal and plant life. I sometimes think of the paleogeographic aspect of geologic history as the scenery back of the drama, while the fossils are the actors. The study of the great adventure of moving from the marine to the terrestrial environment, with all the hazards and problems it involved, provides the student with much opportunity to think. So too does the problem of

adaptation to a changing environment. Illustrations of the failure to survive and of the loss of function in parts due to disuse give all of us cause for reflection.

What does the evidence of the fossils mean? Although I am quite ready to admit that conclusions in an elementary course have to be of a tentative nature, I think it fair to say that a course like historical geology can teach the student a great deal about how to weigh evidence to arrive at a reasonable conclusion. The opportunity to teach something about the scientific method of thinking to young people is one that every teacher should welcome. It is my conviction that if we could train a larger percentage of our people to subject public questions to the scrutiny to which a scientific theory is subjected, they would not be fooled by a lot of the schemes which the public now swallows.

One final word about the subject of evolution: It has always seemed to me that the teacher of historical geology would do well to be quite modest in his claims and to point out, even as Darwin did, that there are great gaps in our fossil record and that not all the evidence is yet in. I like a statement by R. C. Moore: "There is need to distinguish between evolution (which Darwin demonstrated and which no competent modern biologist questions) and <u>how</u> evolution is accomplished (which Darwin did not prove and which is not get adequately known.)"

Students have so many courses based on <u>books</u>. We don't depreciate their value, but when the student comes in contact with nature and deals not with "written stuff" but with what are to him "actual facts," he usually catches fire. I believe we teachers of geology have a great privilege in opening the pages of the earth's own autobiography and helping the student to interpret its inspiring pages.

Reprinted by permission, from Collier's magazine for October 18, 1947.

U of L
Susi Steinitz
"To the undergraduate with an eager mind, paleontology, which is the study of fossil remains, can be one of the most fascinating subjects in the curriculum"
COLLIER'S
SUSI STEINITZ

This is obviously not one of Professor Robertson's students!

USE OF HAND SPECIMENS IN PETROLOGY LABORATORY

A. O. Woodford
Pomona College

Petrology is largely the application of physical chemistry to the interpretation of rock masses which must be studied primarily in the field. Field study is commonly supplemented by extensive laboratory work on selected samples, especially by the methods of microscopic petrography. But here an educational problem appears. Most undergraduate students of geology, headed for the oil fields, do not have time for thorough grounding in petrology. As a result, a three or four unit, one semester course in petrology without the microscope must, in many institutions, be considered a terminal course rather than an introduction to the further study of rocks. This paper deals with the laboratory part of such a course. It will be assumed that about ninety hours are available for field and laboratory work and that about eighty of these hours will be spent indoors. It is further assumed that students begin the course with adequate knowledge of the rock-forming minerals--especially crystal forms, habit, twinning and cleavage--and also have, or soon acquire, some familiarity with the principal rock textures.

Laboratory work will then be entirely or almost entirely the inspection or study of hand specimens of rocks. The question becomes: which shall it be, inspection or study?--inspection of many specimens, labelled or unlabelled, or study of a few, unlabelled and to be determined as rigorously and accurately as possible with a hand lens? I prefer the second alternative, carried to the limit. At the very start give the student a tray of forty or fifty unlabelled rock specimens, his assignment for the whole course. I first saw this done in the Berkeley laboratory presided over by Dr. George D. Louderback.

Professor Louderback laid plans for such a course

previous to 1906, while he was teaching at the University of Nevada, but did not bring it to full fruition until the year 1909-10, at Berkeley. In this same year Dr. W. S. Tangier Smith introduced a somewhate similar course at the University of Nevada, but most of the courses of this type at other western institutions probably stem from the one at Berkeley.

Professor Louderback, in a letter dated March 12, 1952, has kindly furnished the following comments, among others.

> "Some years later (after 1910) on a trip east I visited a number of universities, and . . . was greatly surprised at the absence of a corresponding course . . . as I had expected to get some pointers to improve the course here. Several used a set of labelled hand specimens to give a general recognition of the simpler and more obvious rock types. The way I handled the matter was considered a sort of rudimentary petrography and the prevailing belief was that 'petrography' was a specialty and not for the general geologist.
>
> "My underlying purpose was to teach the nature and recognition of such textures, structures, and composition elements as could be recognized with the aid of a lens, . . . (in order to) give the student the ability to determine in the field the conditions of origin and approximate classification of a rock. I felt that satisfactory field work in an area involving a variety of rocks of various origins could be carried out effectively and with the least waste motion only with such mental equipment.
>
> "Students transferring to Berkeley from whatever part of the U. S., even if they had been exposed to rocks in hand specimens, were found consistently to need the experience of the course to fit them for satisfactory work in field courses or personal field work in this region."

The rock specimens furnished the student may be trimmed to fairly small size, say 2 x 3 x 1 inches. Any one of the fifty specimens in the tray may be any kind of rock, but No. 1 may well be a coarse-grained granitic rock, perhaps containing orthoclase, plagioclase, hornblende, and biotite. The No. 1's in the different trays should not look alike unless they are actually different. One large face of No. 1 should be polished, and the opposite face should be roughly broken but nearly plane. The student will spend six to nine hours on No. 1. He will draw enlarged representations of a small portion of the polished surface, and of a corresponding portion of a nearly plane rough surface. Colored pencils are useful. The student should describe in detail the texture, and each mineral (or other component, such as glass) present. He should also estimate mineral percentages, name the rock, give reasons for his choice of rock name, and suggest the probable conditions under which the rock formed. This first specimen is the critical one. The instructor should carefully check each statement and a large part of each drawing. Imaginary textural features, copied from textbook illustrations, will appear in some drawings. These must be rooted out, and the student made aware of his crime.

Only No. 1 need have a polished surface. Drawings for the first ten specimens only may be required, or for the first six plus any new textures that may appear later.

The instructor should use the same methods of identification as the student. Ideally he should have no prior knowledge of the specimens' sources, compositions, or textures. If convenient he should work beside the student and be an example to him. For one thing, the student will see that what took him six hours the instructor can do in fifteen minutes. The student can hope that at the end of the course his own speed will have improved. Some minerals and some textures may be indeterminate to the instructor. This should be admitted frankly.

Each tray should be renovated before it is used again. Battered, broken, or dirty specimens should be retrimmed or replaced. The student deserves clean, fresh rocks to struggle with.

The student who has completed such a course has acquired a technique which will be useful to him in many varieties of geologic endeavor. If he maps in crystalline terrains he can acquire some idea of his rock types before he returns to his laboratory. If he is a mud smeller for an oil company he can recognize a diabasic dolerite even if the rock is so full of calcite that it bubbles like a limestone. He can describe conglomerates that are not composed exclusively of chert and quartzite. He may even recognize a palagonitic tuff and know its significance. Surely he will not let a well be drilled hundreds of feet into basement serpentine on the idea that the easy going means Miocene shale.

A THREE-DIMENSIONAL TEACHING AID IN STRUCTURAL GEOLOGY

Chauncey D. Holmes
University of Missouri

Most teachers of structural geology will perhaps agree that one of the commonest limiting factors is the difficulty students have in visualizing in three dimensions. The aim in a structural geology course is not primarily to "find the right answer," which can sometimes be done by making a few rule-of-thumb measurements and then consulting a table in the back of the book, but rather to gain a familiarity with the essential three-dimensional aspect of the Earth's crustal units and their interrelations. The particular problem is then brought clearly into focus and the steps necessary to its solution become apparent.

Distances and dimensions in a structural problem are easily measured and diagrammed. The difficult part is to deal with angular relationships, particularly those that lie in inclined planes. One of the most helpful recent contributions in this field is the paper by Bucher[1] on the use of the stereonet, the essentials of which are illustrated in Figure 1. This hemisphere projection was devised about 100 B.C. by the Greek scholar Hipparchus, who also invented trigonometry. Its characteristic features are, first, the right-angle relationship of the parallels and meridians, which gives to any point on the projection its true direction from the center. Second, the scale varies in all directions outward from the center, which makes impracticable any measurement of distance on the projection. Its use in structural geology is solely for the purpose of manipulating angles. It is a device or tool for use in preparing a map, but it is not to be thought of as a map itself. To many students, the projection is mostly a baffling system of curved lines.

---

[1]Bucher, W. H. (1944) "The stereographic projection, a handy tool for the practical geologist." Jour. Geol., Vol. 52, pp. 191-212.

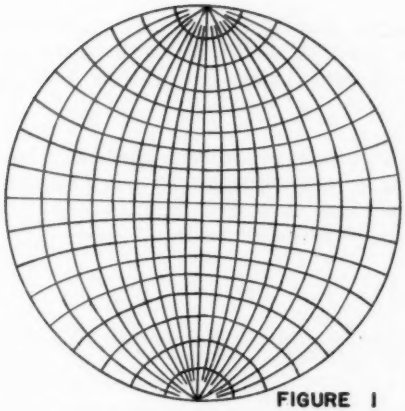

FIGURE 1

INTERVALS OF 2 DEGREES COMMONLY USED

To aid students in comprehending the application of the stereonet, the author has used a transparent plastic hemisphere (Fig. 2) about 10 inches in diameter, purchased as a war-surplus item.[2] As received, the northern and southern hemispheres were

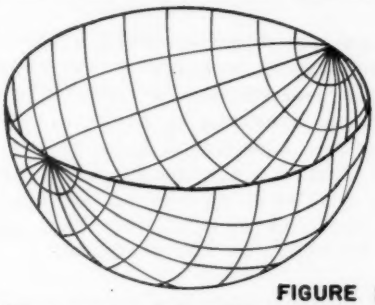

FIGURE 2

(ONLY PART OF THE MERIDIANS AND PARALLELS ARE REPRESENTED.)

separate and had to be welded with a soldering iron. Then the resulting globe was sawed along opposite meridians, making hemispheres corresponding to the stereonet. In use, the sawed periphery of the hemisphere represents the horizontal plane beneath

---

[2]Globes of the type described may be secured from the Farquhar Transparent Globe Co., 3727 Spruce St., Philadelphia, Pa.

which structural surfaces dip and structural lines plunge. The central point in this plane is common to any and all such lines and planes that are to be represented.

For showing how a stereonet meridian represents a dipping plane, a cardboard is cut and mounted on a straight wire axis as shown in Figure 3. The ends

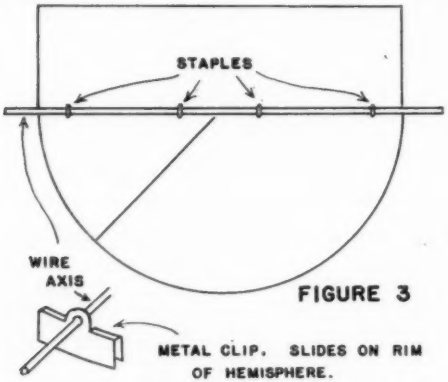

FIGURE 3

of the axis are supported by metal clips as illustrated. A line drawn radially on the cardboard illustrates the measurement of rake (pitch), and its plunge can be measured by placing its lower end against either the equatorial line or the central meridian. If desired, a straight wire can be attached normal to the cardboard at its center point for illustrating the pole of a plane. Each step is followed and repeated on the stereonet.

Two intersecting planes are represented by two circular interpenetrating cardboards (Fig. 4), which can be placed in any desired position in the hemisphere. One or more segments of a third plane can be fitted normal to the other two for demonstrating acute and obtuse bisectrices.

The device for illustrating rotation of a structural plane on an axis other than its strike is shown in Figure 5. The circular cardboard is supported on the wire axis by means of adjustable wire braces attached to the axis on each side. The position of

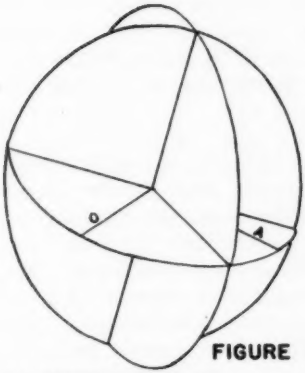

FIGURE 4

O = OBTUSE BISECTRIX

A = ACUTE BISECTRIX

the cardboard can be adjusted by bending these braces to the desired angle. In diameter, the disk should be small enough to turn freely in the hemisphere. The latter may not be geometrically accurate. By coloring or shading one half of the disc, it is easier to follow the movement of that portion of the disc utilized at the beginning of rotation. Of course the student must understand that the circular or semicircular sections are used only for the convenience of working within the hemisphere.

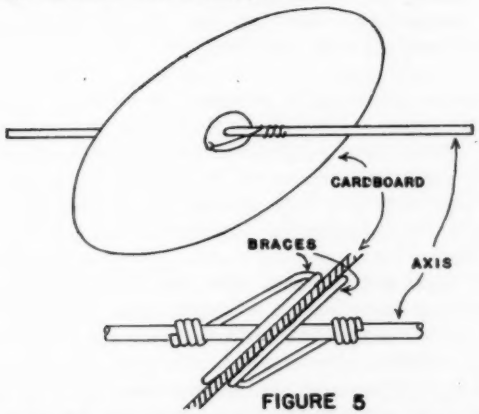

FIGURE 5

Additional types of demonstration can be worked out with the hemisphere by constructing appropriate models of cardboard or other suitable material.

THE SEMINAR AS A SENIOR "POLISHING" COURSE IN GEOLOGY

John Eliot Allen
New Mexico Institute of Mining and Technology

Geologic work generally culminates in the preparation of a written or oral report presented for publication or to one's superior or employer. The effectiveness of the report depends upon the degree of communication achieved. Unless the worker in geology can clearly and concisely communicate his ideas and conclusions his work is largely wasted, no matter how important it may be. Unfortunately, many senior students in geology have gone through high school and three years of college without gaining any appreciable degree of ease, much less facility, in expressing themselves on paper or on their feet. The geology seminar, beyond its function of presentation and discussion of factual material, is therefore an exercise in communication, with all that this implies.

Report-making in the seminar also gives the student training in promptness, accuracy, completeness, originality, and ability in evaluation. It emphasizes furthermore an often neglected phase of undergraduate training: the preparation of bibliographies and proper use of the library.

Another function of the seminar is that it helps the student make a good impression on potential employers. Many schools do little to prepare their graduates for the exigencies of getting their first job. We believe that the seminar gives valuable training in this respect.

Let me describe briefly the mechanical operation of the geology seminar as given at the New Mexico Institute of Mining and Technology. Both graduate and senior undergraduate students meet in the same class. The graduate students are required to present one formal written report per semester in addition

to their oral reports. For his oral reports the student selects at the beginning of the semester two topics in line with his individual interests. These topics, after approval by the instructor, are sorted according to subject matter, and reports are scheduled for the seminar meetings (two hours per week) during the semester. Ordinarily a student gives four oral reports each semester.

At least two weeks before his oral report a student is expected to discuss his plans with a faculty adviser. A second conference is held after work on the report has reached an advanced stage. Five days before the report is due the student presents a one-page abstract and bibliography for hectographing. Serious penalties are imposed for failure to meet any of the above requirements on schedule.

On the day the student gives his report he first hands out the hectographed copies of his abstract and bibliography. He may speak from brief notes but may not read his paper. The use of charts, blackboard drawings, and lantern slides is encouraged. The talk is timed, and must be from ten to twenty minutes in length. The speaker is stopped abruptly if he goes overtime. During the talk, each member of the geology staff and each of the seminar students fills in a "critic sheet" (Fig. 1) analysing the presentation. A period of time equivalent to the time taken by the speaker is allotted to discussion, the emphasis being on student participation. The professors, as a matter of policy, withhold their comments until student discussion is no longer forthcoming. After the seminar, the student and faculty critic sheets are averaged separately, and the two resulting grades are again averaged to give a final grade for the report. All sheets are then returned to the student, who may see just where he was defective in his preparation and presentation.

Note that in the makeup of the critic sheet emphasis is placed upon the effectiveness with which the student communicates his ideas. The content of

CRITIQ SHEET

Seminar members will fill out this sheet, giving footnote reasons for each deduction from the total possible grade. These sheets will be handed to the student making the talk, so he can improve his presentation.

Name of Student:_____Date:_____19___

Title of talk:_____

50% CONTENT AND ORGANIZATION

Effective introduction and opening.	____ 5%
Abstract adequately presented; bibliography sufficient.	____10%
Illustrations striking, pertinent, and legible.	____10%
Material well selected, well organized, and well timed.	____15%
Adequate discussion and evaluation of bibliography, with effective summary and conclusions.	____10%

40% DELIVERY

Presentation without notes, or with inconspicuous use of notes. Eye contact with audience good (Don't talk to the wall or to your notes.)	____15%
Posture erect and natural. Gestures adequate and emphatic. No disturbing mannerisms. Neat personal appearance and dress.	____10%
Grammar correct and vocabulary adequate.	____ 5%
Pronunciation correct. Enunciation clear. Voice well modulated, and well pitched.	____10%

10% QUESTIONING

Knowledge of content of papers reviewed and related subjects.	____ 5%
Ability to reply briefly and to the point.	____ 5%

REMARKS (Use index numbers to locate above):

1)

2)

3)

4)

5)

6)

Fig. 1

any report, although it may be of vital interest to the audience, may not "get across" unless the presentation is good. On the critic sheet content is rated at only 50%, and some of even this percentage depends on proper delivery. Grammar, vocabulary, pronunciation, enunciation, and voice modulation may strongly affect the overall impression on the audience and the degree to which the report "gets across." So too may other attributes of the speaker such as his ability to establish eye-contact, his personal appearance, and his use, or misuse, of gestures.

Eye-contact involves looking the members of the audience in the eye--not over their heads, at the blackboard or illustrations, or out the window. It is a technique of fastening the gaze for short intervals on different members of the audience so that each person in the room gets the feeling that he is being spoken to personally.

Personal appearance is not, unfortunately, always regarded as being important in the classroom, although it may make a big difference when the graduate applies for a job. During interviews of students by oil company representatives last year I was much disturbed to see that several students met their interviewers unshaven, in T-shirts and moccasins. In seminar we are now going to the perilous extreme of suggesting the wearing of neckties, although we still do not require a suit coat!

Gestures with the hands to emphasize important points may be used very effectively in any talk. However, eccentric gestures, such as fiddling with note-cards, neckties, or coins in pockets, may be very distracting. Apparently most people do not know what to do with their hands while speaking. They have to learn to let them hang naturally at their sides when not in use. There are innumerable other disturbing tricks of which speakers are seldom conscious--such as head scratching, rocking on the heels, and leaning on the desk or against the wall. All such tricks are disturbing to the audience and

should be pointed out for elimination.

By the senior year, it is almost too late to try to do anything for a student in the way of improving his grammar and vocabulary, but at least we can attempt to correct the more flagrant errors which he continues to make. And we can suggest improvements in pronunciation, enunciation, and in the pitch of the voice and its modulation for effect. We cannot make the student, like Demosthenes, practice with pebbles in his mouth (even if he is a geologist), but we can show him how to stop mumbling and how to get his voice out and to the back of the room!

As regards vocabulary: the overuse of technical terms, particularly when it degenerates into jargon, is criticised. Far too many students have the idea that a good technical report consists of making ten words do for one.

It will be noted that points on the critic sheet are awarded for evaluation of the literature which the student has reviewed. We try to make sure that the student does not simply parrot the author examined--that he actually contributes, if not some ideas, at least some opinions on the value of the paper derived from his own experience or from related references.

Finally, the originality displayed by the student in his method of presentation, including his use of exhibits, charts, and lantern slides, strongly affects his final grade.

One effect of the critic sheet upon the student speaker has been brought to our attention by the students themselves, who complain it is disconcerting and disturbing to be graded while they are giving their talks. Our reply is that we want it to be! We are trying to teach them to do their best under trying conditions. Certainly the class situation is not so disturbing as the usual scientific meeting. There the neophyte presenting his first paper may

follow on the program some outstanding scientist, and as he gets up to speak may find that half his audience has walked out while the other half has congregated in a corner for an old-home-week get-together. The students who listen sometimes complain that having to fill in the critic sheet distracts them from the subject matter of the talk itself. If, however, one is required repeatedly to note the flaws in others' presentations, one's own presentation is bound to benefit.

The same considerations as regards content, organization, grammar, vocabulary, etc. which apply to oral reports also apply to written reports, with the addition that the student must be impressed with the fact that he is making a permanent record, not only of his abilities, but of his sins as well. Hence he must apply even more care in making the written report. Perhaps this very recognition of the public nature of the written report is the reason for the frequent appearance of jargon, obscurity, and redundancy in such reports. The story is told of Dr. Charles Berkey of Columbia University that he was once visiting one of his ex-students, a junior geologist on a large construction project. The young man had just completed and submitted a comprehensive and rather technical sixteen-page single-spaced report on geologic aspects of the project, in which he had made several recommendations which appeared to him vital. His report had been accepted, but no action had been taken, and the young geologist asked Dr. Berkey why his superiors were so oblivious to the recommendations made. Dr. Berkey asked for a copy of the report, read it over, took a pencil, and on one page wrote out a condensation. He told his former student to have it typed and send it in as his own. This was done; the report was immediately acted upon; and the young man commended for his fine work.

We emphasize conciseness by requiring that the written reports be short enough for presentation orally within the usual twenty-minute time limit.

We make the following suggestions to students regarding the form of their written reports:

1. General appearance and organization. A report is first judged on its appearance.
   a. Maps, charts, graphs, and diagrams should be carefully selected and neatly prepared.
   b. The report as a whole should be well organized and integrated into a connected whole.
   c. Typing and drafting should be neatly done. Proofreading is vital.

2. Expression. A report is judged on the ease and accuracy of its English. The wording should be the author's own--not a series of quotations.
   a. Correct grammar and spelling are essential.
   b. Style should be suited to the subject. Avoid overuse of technical "jargon."

3. Completeness. A report is judged on whether it covers the necessary ground. Does it have an adequate bibliography? Have the references consulted been fully utilized?

4. Accuracy and honesty. A report is judged on the accuracy with which it reports borrowed information and its honesty in fully acknowledging the sources from which all such information has been acquired.

5. Ideas. Finally, a report is judged on whether it adds to our knowledge of a subject--either by making some new synthesis of existing data or by presenting and interpreting new data.

For finding material for both written and oral reports students are directed to make use of the standard bibliographies, plus tables of contents and indices of periodicals and other literature post-dating the bibliographies. That "the library

does not have it" is not accepted as an excuse for failure to consult a particular reference. Students are required to compile their bibliographies early enough so that interlibrary loans may be arranged as necessary.

In addition to these suggestions we expect our seminar students to consult the following references dealing with the preparation and presentation of reports:

Allbutt, T. C., Notes on the Composition of Scientific Papers, MacMillan and Co., 3d ed., 164 pp. (1923).

Croneis, C. G., "Stylistic Infelicities and the Excess Word," Science, n.s., Vol. 85, No. 2215, pp. 562-563 (1937).

DuBois, E. F., "On the Reading of Scientific Papers," Science, n.s., Vol. 95, No. 2463, pp. 273-274 (1942).

Editorial Staff, "Preparation of Manuscripts," A.A.P.G. Bull., Vol. 29, No. 7, pp. 1056-1058 (1945).

Editorial Staff, "Suggestions to Contributors," Jour. Sedimentary Petrology, Vol. 18, No. 3, pp. 129-130 (1948).

Editorial Staff, "Preparation of Manuscripts," Geol. Soc. Amer. Spec. Pub., 6 pp. (1937).

Moore, C. A., "Preparation of Lantern-Slide Copy," A.A.P.G. Bull., Vol. 26, No. 10, pp. 1656-1671 (1942).

Mygdal, K. A., "Suggestions to Speakers," A.A.P.G. Bull., Vol. 35, No. 12, pp. 2594-2608 (1951).

Pence, R. W., The Mechanics of the Term or Research Paper, Manual used at De Pauw University, 27 pp. (1941).

Rickard, T. A., Technical Writing, John Wiley & Sons., 327 pp. (1931).

Ridgeway, J. L., "The Preparation of Illustrations," U.S.G.S., Spec. Pub., 101 pp. (1920).

Wood., G. M., "Suggestions to Authors," U.S.G.S. Spec. Pub., 4th ed., 126 pp. (1935).

In written report-making we emphasize promptness by the use of the "progress report sheet" (Fig. 2), which makes the student responsible for, not one, but several deadlines, and which ensures awareness of the necessity for making sufficient weekly progress in completing the report. This sheet also ensures that inaccuracies or gaps in information and bibliography will be caught by the advising professor and pointed out to the student before it is too late for him to correct errors or add needed material.

In the three or four talks given by each student during the semester, we have noted remarkable improvement by a majority of the class, and we feel that our approach has been amply justified.

PROGRESS SHEET

Copies of this sheet are to be kept on file by supervisor and by advising professor. The student's grade will depend on proper progress throughout the semester as well as on the quality of his reports.

Deadline by week of semester	Progress	Date completed
1	Preliminary report to supervisor.	_____
2	Report to advising professor; subject chosen.	_____
4	Tentative outline submitted with topic headings and bibliography.	_____
6	General conference on progress.	_____
7	"Table of Contents" submitted.	_____
9	First draft submitted for criticism.	_____
11	Final draft submitted for criticism.	_____

_____ Supervisor

_____ Advising Professor

Fig. 2

ARTICLES OF INTEREST TO GEOLOGY TEACHERS WHICH HAVE APPEARED IN WARD'S NATURAL SCIENCE BULLETIN

David E. Jensen
Ward's Natural Science Establishment

In recent years Ward's Natural Science Bulletin has from time to time carried articles which may be of some lasting interest to teachers of geology, especially teachers in the secondary schools. At the request of the editor of the Journal of Geological Education I have prepared a list of such articles which have appeared from 1941 (our Vol. XV) to the present. We have on file, or in storage, a variable number of the different back issues concerned and shall be glad to furnish copies to teachers so long as the supply lasts.

Articles are listed in chronological order. The number of copies available is shown in parentheses.

"How to Arrange Minerals in a Collection." Vol. XV, No. 2, pp. 23-24, Dec. 1941 (25 cop.)

"An Old System of Mineralogy" (Robert Jameson). Vol. XV, No. 3, pp. 50-51, Feb. 1942 (30 cop.)

"The Importance of Typical Rocks and Minerals in Teaching" by D. E. Jensen. Vol. XVI, No. 2, p. 27, Oct. 1942 (101 cop.)

"Mineral Names" by D. E. Jensen. Vol. XVI, No. 3 p. 39, Dec. 1942 (2 cop.)

"James Dwight Dana" (brief biographical sketch) by D. E. Jensen. Vol. XVIII, No. 1, pp. 3-4, Oct. 1944 (125 cop.)

"Dana's System of Mineralogy" (a review) by D. E. Jensen. Vol. XVIII, No. 1, pp. 7, 9, Oct. 1944 (125 cop.)

"The Buying and Selling of Minerals" by R. C. Vance. Vol. XVIII, No. 5, pp. 67-69, June 1945 (25 cop.)

"Science in the Secondary Schools" by D. E. Jensen. Vol. XX, No. 3, pp. 44,46, Jan. 1947 (65 cop.)

"Geological Teaching Materials" by D. E. Jensen. Vol. XX, No. 5, pp. 74,76, May 1947 (120 cop.)
"Geological Teaching Materials (Contd.)" by D. E. Jensen. Vol. XXI, No. 1, pp. 10,14, Sept. 1947 (230 cop.)
"Notes on Microscopy" by K. J. Heinicke. Vol. XXII, No. 2, pp. 22-24, Nov. 1948 (195 cop.)
"The Fine Art of Mineral Collecting." Vol. XXIII, No. 3, pp. 40-42, Jan. 1950 (25 cop.)
"The Embedding of Ore Samples in Bioplastic." Vol. XXIII, No. 4, pp. 59-59, Mar. 1950 (225 cop.)
"First Steps in Field Collecting of Fossils." Vol. XXIII, No. 5, pp. 75-76, May 1950 (20 cop.)
"A Device for Projecting Thin Rock Sections" by E. F. St. Mary, Jr. Vol. XXIV, No. 2, pp. 22-23, Nov. 1950 (100 cop.)
"Laboratory Synthesis of True Quartz Crystals" by A. C. Walker. Vol. XXIV, No. 3, pp. 42,46, Jan. 1951 (40 cop.)
"The Trilobite" (use in teaching). Vol. XXIV, No. 4, pp. 54-55, Mar. 1951 (20 cop.)
"Stanford University Mineral Club." Vol. XXIV, No. 4, pp. 61-62, Mar. 1951 (20 cop.)
"The Training of Geologists in Indonesia" by Th. H. F. Klompe. Vol. XXIV, No. 4, p. 63, Mar. 1951 (20 cop.)
"Note on Preparing Bases for Mineral Exhibits" by J. H. Benn. Vol. XXV, No. 1, pp. 12-13, Sept. 1951 (430 cop.)